REMARKS/ARGUMENTS

Favorable reconsideration of this Application, as presently amended and in light of the following discussion, is respectfully requested.

This Amendment is in response to the Office Action mailed on October 22, 2003. Claims 1 and 2 are pending in this Application and stand rejected. Claims 1 and 2 are being amended and new Claims 3-5 are being added by the present amendment.

The Specification was objected to for not being in proper idiomatic English. According to 37 C.F.R. §1.121, Applicants have submitted herein a substitute Specification in compliance with 37 C.F.R. §1.52(a) and (b) and respectfully request reconsideration of the same. As required, Applicants are submitting both a substitute Specification in clean form and another version of the substitute Specification marked up to show all changes relative to the previous version. Applicants state that the corrections made to the substitute Specification do not add any new matter to this Application and have been implemented only to improve the reading of Applicants' Disclosure.

Claims 1 and 2 stand objected to because of several informalities. Applicants have amended Claims 1 and 2, including correction of the cited informalities, and respectfully request reconsideration of the objection thereto.

Claims 1 and 2 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Johnston (U.S. Patent No. 5,153,050, hereinafter "Johnston") in view of Takahashi et al. (U.S. Patent No 4,526,835, hereinafter "Takahashi").

Applicants respectfully submit that Johnston, and Takahashi, individually or in any combination thereof, do not support a *prima facie* case of obviousness of the invention recited in the presently amended independent Claim 1. This is so because, even when combined, these prior art references do not teach or suggest all the claim limitations recited therein.

According to a feature of the invention as set forth in the presently amended Claim 1, a method of manufacturing a multilayer circuit board, is recited, comprising, among other limitations: stacking the printed boards, each printed board having a via hole extending through the insulating substrate to the conductor layer, the via hole being filled with a plate conductor, the plated conductor being formed with a conductive bump extending through the bonding layer so that the conductive bump is connected to the conductor layer of the other stacked printed board; stacking an outermost conductor layer on an insulating layer side of a first outermost printed board with a bonding layer being interposed there between, and pressing the stack so that the printed boards and the outermost conductor layer are bonded together.

As disclosed in the Specification, manufacturing of core boards in conventional multilayer boards require a step of bonding a copper foil by several pressing steps since the manufacturing process involves a sequence of stacked core board. Accordingly, as the number of layers increase, there is a definite limit on how much the manufacturing efficiency can be improved while the individual repeated pressing steps distort the insulating substrate of the core board, thereby displacing the via holes formed in the insulating substrate. In order to avoid these problems, prime surface area in the board needs to be rendered larger, making it difficult to accomplish the ever increasing demand of miniaturization of the multilayer circuit board. Additionally, when insulating substrates are stacked on the core board, the multitude of pressing steps causes misregistration between the core substrate and each insulating board. In order to avoid this problem, an X-ray check hole is previously formed so that the location of the inner conductor circuit may be checked from the surface of the insulating board. It is clear that the need to provide such an additional hole requires an extra step in the manufacturing process of the multilayered board (Specification, page 1, line 10 – page 2, line 20).

In the present invention, printed boards are collectively pressed into a multilayer circuit board in a single pressing operation, thereby significantly improving the efficiency of the manufacturing process. Furthermore, since pressing is carried out just once, the possibility that the insulating substrate may be distorted and the possibility that the printed board may be shifted can be significantly minimized or completely eliminated. In addition, another novel and non-obvious feature of the present invention is the fact that the possibility of distortion and displacement can be rendered minimum by the application of a uniform pressure to the entire printed board in the pressing manufacturing process because the outmost printed boards are not previously etched and pressed under a condition wherein their thickness is entirely uniform. Consequently, the overall precision of the multilayer circuit board can be improved (Id., page 3, line 12 – page 4, line 5). Applicants respectfully submit that presently amended Claim 1 more clearly recite such a process of manufacturing multilayered circuit boards.

The claimed invention has the following features: (1) a via hole formed in each printed board so as to extend through the insulating substrate to the conductor layer, the via hole being filled with a plated conductor; (2) a plated conductor formed in the via hole; (3) a conductive bump formed in the plated conductor; (4) A plurality of printed boards stacked with the bonding layer being interposed between the printed boards so that the conductive bump extends through the bonding layer; and (5) the conductive bump extending through the bonding layer is connected to the conductive layer of another substrate.

In view of features (1) and (2), a step of forming through hole after stacking can be eliminated since the insulating substrate is previously provided with electrically conductive means. In further view of features (3), (4) and (5), the conductive bump provides an electrical connection to the conductive layer of another substrate and physical connection can be made between the conductive layer and the via hole. Further, the conductive bump is

made from a material with a low melting point. Accordingly, the conductive material melts down when the substrates are pressed in the stack, assuring the easy adhesion of the conductive bump to the conductive layer. Further, since the conductive bump also extends through the bonding layer, interlayer connection is made easier.

Johnston discloses a method of making a multilayered printed board by stacking printed boards by means of prepregs. His invention teaches a conventional 6 layer multilayer lay up of two PC boards, including a first separator layer 2, a first outer copper foil layer 4 placed upon the separator sheet 2. Upon the copper is placed a laminated multilayer core, identified collectively as element 10, including three double plies 12 of prepreg and two double sided boards 14 pre-etched with conductive paths 15 on both surfaces. Upon this inner core laminate 10 is another sheet of copper foil 4 with an oxidized surface 16 laid upon the core 10 and with its upper or working surface 18 in engagement with another separator sheet 2. Another book, identical to the first, is shown disposed on the upper surface 24 of the upper separator sheet 2, including copper foil layer 4, another core 10 and then a foil layer 2 (Johnston col. 4, lines 23-57).

It is clear from the above-noted summary of Johnston that this prior art reference cannot obviate a method in which each printed board has a via hole extending through the insulating substrate to the conductor layer filled with a plate conductor being formed with a conductive bump extending through the bonding layer so that the conductive bump is connected to the conductor layer of the other stacked printed board. There are at least no via holes extending through the insulating substrate to the conductor layer in Johnston and Johnston is silent with respect to filling the via holes with a plate conductor formed with a conductive bump extending through the bonding layer so that the conductive bump is connected to the conductor layer of the other stacked printed board during pressing of the assembly.

The outstanding Office Action acknowledges that Johnston shows that his printed boards comprise an insulating layer having conductors on its upper and lower surfaces. The Examiner cites Takahashi as disclosing "printed boards comprising an insulating laryer with conductors required only on at least one surface thereof." Takahashi discloses a method of stacking printed boards by means of prepreg into a multilayered printed board and thereafter, forming through holes. Nevertheless, such a teaching and disclosure of Takahashi does not remedy the above-noted deficiency of Johnston.

Therefore, Johnston, and Takahashi, individually or in any combination thereof, do not make obvious the invention recited in the presently amended Claim 1. Furthermore, Claim 2 is allowable, among other reasons, as depending directly from Claim 1, which is allowable. For the foregoing remarks, Applicants respectfully request that the Examiner withdraw the rejection of Claims 1 and 2 under 35 U.S.C. § 103(a).

Finally, Applicants have submitted herein new Claims 3-5, which is supported by subject matter disclosed on page 6, lines 5-15 of Applicants' Disclosure. Because Claims 3-5 incorporates by reference all of the limitations of Claim 1, in view of the above-presented remarks, Applicants respectfully submit that new Claims 3-5 are allowed over Johnston and Takahashi.

Based at least on the foregoing reasons, Applicants believe the present application is in condition for allowance and respectfully solicit an early Notice of Allowability of Claims 1-5.

Respectfully submitted,

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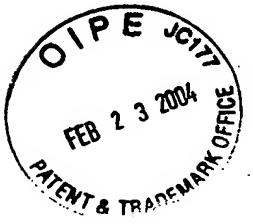
~~DESCRIPTION~~ Title of the Invention



METHOD OF MANUFACTURING MULTILAYER CIRCUIT BOARD

~~TECHNICAL FIELD~~BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a method of manufacturing a multilayer circuit board.

~~BACKGROUND ART~~

(2) Description of Related Art

The build-up process is well known as a conventional method of manufacturing a multilayer circuit board. For example, a multilayer circuit board is manufactured as follows in this process. Firstly, via holes are formed at prescribed positions in a one-side copper-clad laminate manufactured by applying a copper foil to one side of an insulating substrate. The via holes are filled with an electrically conductive paste. A copper foil is bonded to the insulating substrate side of the one-side copper-clad laminate by pressing. ~~The copper foil is~~ etched so that a prescribed conductor circuit is formed.

A ~~both~~ printed board manufactured as described above serves as a core board. Insulating substrates are stacked on both sides of the core board respectively and bonded by pressing. Thereafter, via holes are formed at prescribed positions and then filled with the conductive paste. After copper foils are stacked on both sides of the board and pressed again, prescribed conductor circuits are formed on each copper foil. This step is repeated ~~for~~ to further increase ~~in~~ the number of layers so that a multilayer circuit board is manufactured.

In the foregoing method, the ~~both~~ printed board serving as the core board is manufactured and circuit patterns are sequentially stacked on the core board. Accordingly, since the number of steps is increased, there is a definite limit ~~in improvement of~~ on how much one can improve the manufacturing efficiency.

Furthermore, manufacture of the core board requires a step of bonding a copper foil by pressing in ~~the~~ a conventional method. The pressing sometimes distorts the insulating substrate of the core board, ~~whereupon~~ causing positions of the via holes formed in the insulating substrate are sometimes displaced. Accordingly, ~~a land~~ the work space needs to be rendered larger in ~~consideration of allowance~~ view of the need to allow for displacement. This results in a problem that densification of the multilayer circuit board is made difficult.

Additionally, when the insulating substrates are stacked on the core board, the pressing sometimes causes misregistration between the core substrate and each insulating board. Accordingly, an X-ray check hole needs to be previously formed so that the location of the inner conductor circuit is checked from the surface of the insulating board. This necessitates one extra step in the manufacture.

~~DISCLOSURE OF THE INVENTION~~BRIEF SUMMARY OF THE INVENTION

~~A~~ The first embodiment of the invention is a method of manufacturing a multilayer circuit board, in which a plurality ~~of~~ printed ~~board~~ boards are stacked and pressed into a multilayer circuit board, each printed board having a conductor layer on one side of an insulating layer, characterized by the steps of stacking the printed boards with a bonding layer being interposed between the printed boards, and stacking an outermost conductor layer on an insulating layer side of a first outermost printed board with a bonding layer being interposed therebetween and pressing a stack so that the printed boards and the outermost

conductor layer are bonded together, the first outermost printed board being disposed with the insulating layer side being directed outward.

~~A second~~ Another embodiment of the invention is characterized in that the printed boards include a second outermost printed board disposed with a conductor layer side being directed outward, the conductor layer being pressed under a condition ~~where~~ as to ensure that the conductor layer has a uniform thickness ~~all over~~throughout.

According to the first ~~invention~~embodiment, the printed boards each of which has one side formed with a conductor layer are stacked. The outermost conductor layer is stacked on the insulating layer side of the first outermost printed board disposed with the insulating layer side being directed outward. The printed boards are collectively pressed to be manufactured into a multilayer circuit board. Accordingly, the multilayer circuit board is manufactured by a single pressing operation. Consequently, the manufacturing steps can be simplified and the manufacturing efficiency can be improved.

Furthermore, since pressing is carried out just once, the possibility that the insulating substrate may be distorted and the possibility that the printed board may be shifted can be rendered minimum. Consequently, the precision of the multilayer circuit board can be improved.

According to the second embodiment of the invention, the second outermost printed board is not previously etched and pressed under the condition where the thickness thereof is entirely uniform. Accordingly, since a uniform pressure is applied to the whole printed board in the pressing, the possibility of distortion and displacement can be rendered minimum. Consequently, the precision of the multilayer circuit board can be improved.

~~BIREF~~ BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view (1) showing steps of manufacturing a multilayer circuit board ~~of one embodiment~~ in accordance with the present invention;

FIG. 2 is a sectional view (2) showing steps of manufacturing a multilayer circuit board ~~of the embodiment~~ in accordance with the present invention; and

FIG. 3 is a sectional view (3) showing steps of manufacturing a multilayer circuit board ~~of the embodiment~~ in accordance with the present invention.

~~BEST MODE FOR ENFORCEMENT OF THE INVENTION~~DETAILED DESCRIPTION OF THE INVENTION

One embodiment of the present invention will be described with reference to FIGS. 1 to 3.

In the method of manufacturing the multilayer circuit board 1 in accordance with the present invention, a plurality of printed board 2 are stacked and collectively pressed. The method is characterized by stacking an outermost copper foil 6 (corresponding to an outermost conductor layer of the present invention) on a side of a first outermost printed board 2A at an insulating substrate 4A side and pressing, the printed board 2A having an insulating substrate 4 (corresponding to an insulating layer in the present invention) side being directed outward. See FIG. 2(G).

The method is further characterized in that a copper foil 5B of a second outermost printed board 2B disposed with the copper foil 5B (corresponding to a conductor layer in the present invention) side being directed outward is not previously formed with a conductor circuit 10 and is pressed under a condition where the copper foil 5B remains on the ~~whole~~ entire side.

The manufacture of the printed board 2 forming the multilayer circuit board 1 starts with a one-side copper-clad laminate 3. The one-side copper-clad laminate 3 has a well known structure, that is, the copper foil 5 is affixed to ~~overall~~ one side of an insulating substrate 4 (the underside in FIG. 1) made of a plate-shaped glass-cloth epoxy resin (FIG. 1(A)).

Laser beams are irradiated onto prescribed locations on the insulating substrate 4 from the side of the substrate opposite the copper foil 5 (the upper side in FIG. 1) so that via holes 7 extending through the insulating substrate to the copper foil 5 are formed (FIG. 1(B)). The laser beam machining is executed by a pulse oscillation CO_2 gas laser, for example. In this case, the pulse energy preferably ranges between 2.0 and 10.0 mJ, the pulse width preferably ranges between 1 and 100 μs, the pulse interval is preferably at or above 0.5 ms, and the number of shots preferably ranges between 3 and 50.

Thereafter, desmearing is carried out in order that the resin remaining in the via holes 7 may be removed. The desmearing includes a treatment of potassium permanganate, oxygen plasma discharge, corona discharge process, etc.

Subsequently, the copper foil 5 is covered with a protecting film made from polyethylene terephthalate although this state is not shown. In this state, a plated conductor 8 is formed in each via hole 7 by an electroplating with the copper foil 5 serving as one of electrodes (FIG. 1(C)). An amount of conductor 8 filling each via hole 7 is preferably determined so that an upper face thereof is slightly lower than the surface of the insulating substrate 4. Copper is most preferably as a plated metal, but ~~may be~~ any metal which can be plated may be used, such as tin, silver, solder, alloy of copper and tin, alloy of copper and silver, etc.

An electrically conductive bump 9, comprising a material with a low melting point, such as tin, is formed by means of bump plating so that the bump overlaps the plated

conductor 8 in each via hole 7. Each conductive bump 9 is formed so as to project slightly from the upper surface of the insulating substrate 4 (FIG. 1(D)). Subsequently, the copper foil 5 is etched so that a conductor circuit 10 is formed after the protecting film is stripped from the copper foil 5 (FIG. 1(E)).

A thermosetting adhesive (epoxy resin adhesive, for example) is applied by roll coating to the side of the printed board 2 on which the conductive bumps 9 are formed, whereby an adhesive layer 11 is formed (FIG. 1(F)).

A plurality of printed boards 2 manufactured as described above are aligned and overlapped (FIG. 2G). A second outermost printed board 2B of the top layer is overlapped without being etched. Accordingly, the copper foil 5 remains on the printed board 2B with a uniform thickness over the whole surface. The printed board 2B is disposed so that the copper foil 5 is directed outward (upward in FIG. 2) and the conductive bumps 9 are directed inward. The printed board 2 located below the printed board 2B is stacked so that the conductor circuits 10 are positioned at the upper side of the printed board 2. Thus, the printed boards are stacked so that the conductive bumps 9 of the printed board 2 located ~~upward~~ on top are connectable to the conductor circuits 10 of the lower printed board 2. Additionally, a first outermost printed board 2A located lowermost is stacked so that the insulating substrate 4A side formed with the adhesive layer is directed outward (downward in FIG. 2). An outermost copper foil 6 is stacked on the surface of the printed board 2A.

The printed boards thus stacked are heated and pressed under vacuum at 180°C for 70 minutes so that the adhesive layer 11 is hardened, whereby the printed boards 2, 2A and 2B, and the outermost copper foil 6 are bonded together. The multilayer circuit board 11 in which the printed boards 2, 2A and 2B and outermost copper foil 6 are integrated is manufactured by one pressing operation (FIG. 2(H)). The distal ends of the conductive bumps 9 of each printed board are connected to prescribed locations of the conductor circuit

10 on the adjacent printed board 2, whereupon the conductor circuits 10 of the adjacent printed boards 2 are electrically connected to each other.

Subsequently, the copper foil 5 on the uppermost side and the outermost copper foil 6 affixed to the underside are etched so that conductor circuits 10 are formed (FIG. 3(I)).

A photosensitive solder resist 12 is applied to the whole underside and exposure and development processes are applied to the solder resist in a prescribed pattern so that the solder resist 12 is formed with openings which open lands formed at prescribed locations on the conductor circuit 10. Pins 13 for connecting the multilayer circuit board 1 to other components are bonded to the lands by solder 14. The multilayer circuit board 1 is thus manufactured.

According to the foregoing embodiment, the multilayer circuit board 1 is manufactured by stacking a plurality of printed boards 2 and stacking the outermost copper foil 6 on the insulating substrate 4A side of the first outermost printed board 2A disposed with the insulating substrate side being directed outward, and collectively pressing the stack. Accordingly, the multilayer circuit board 1 can be manufactured by a single ~~time of~~ pressing. Consequently, manufacturing steps can be simplified and the precision of the multilayer circuit board can be improved.

Furthermore, since pressing is carried out just once, the possibility that the insulating substrate 4 and the via holes 7 may be displaced can be rendered minimum. Consequently, the precision of the multilayer circuit board can be improved.

Furthermore, the copper foil 5B of the second outermost printed board 2B disposed with the copper foil side being directed outward is not previously etched, and the printed board 2B is pressed under the condition where the copper foil 5B ~~having~~ has a uniform thickness ~~all over is present~~throughout. Accordingly, a uniform pressure can be applied to the whole printed board 2, thereby minimizing ~~and accordingly,~~ the possibility that the inner

printed board 2 may be shifted or distorted ~~can be rendered minimum~~. Consequently, the precision of the multilayer circuit board 1 can be improved.

The method of manufacturing ~~the~~ a multilayer circuit board 1 just described can be ~~applied~~ used to ~~the~~ manufacture ~~of~~ electronic packages ~~required of~~ requiring a particularly high precision. The underside on which the pins 13 are provided is preferably the outermost copper foil 6 side. The precision required for the lower layer side is lower than the precision required for the upper layer side and accordingly, the precision does not result in a problem even if the outermost copper foil 6 is stacked on the lowermost layer and pressed.

The technical scope of the present invention should not be limited by the above-described embodiment and covers equivalents thereof.

INDUSTRIAL APPLICABILITY

The present invention can provided a method of manufacturing a multilayer circuit board which can simplify the manufacturing steps and improve the precision of the multilayer circuit board.

CLAIMS

1. A method of manufacturing a multilayer circuit board, in which a plurality printed board are stacked and pressed into a multilayer circuit board, each printed board having a conductor layer on one side of an insulating layer, characterized by the steps of stacking the printed boards with a bonding layer being interposed between the printed boards, and stacking an outermost conductor layer on an insulating layer side of a first outermost printed board with a bonding layer being interposed therebetween and pressing a stack so that the printed boards and the outermost conductor layer are bonded together, the first outermost printed board being disposed with the insulating layer side being directed outward.

2. A method of manufacturing according to claim 1, characterized in that the printed boards include a second outermost printed board disposed with a conductor layer side being directed outward, the conductor layer being pressed under a condition where the conductor layer has a uniform thickness all over.

ABSTRACT

A plurality of printed boards are stacked and collectively pressed to be manufactured into a multilayer circuit board. An outermost conductor layer is stacked on an insulating layer side of a first outermost printed board disposed with the insulating layer side being directed outward, and pressed. A conductor layer of a second outermost printed board disposed with the conductor layer side being directed outward is previously formed with no conductor circuit and pressed under a condition where the conductor layer has a uniform thickness ~~all over~~throughout. Consequently, manufacturing steps can be simplified and the precision of the multilayer circuit board can be improved.